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Mazuir et al.

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(54) **SYSTEM AND METHOD FOR ADJUSTABLE LIGHTING BASED ON OCCUPANT AND OBJECT IDENTIFICATION IN A VEHICLE**

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G06K 9/00	(2006.01)
B60Q 1/14	(2006.01)
F21V 14/04	(2006.01)
F21V 5/04	(2006.01)
H05B 47/105	(2020.01)

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(52) **U.S. Cl.**
CPC ***B60Q 1/1423*** (2013.01); ***F21V 5/04*** (2013.01); ***F21V 14/04*** (2013.01); ***H05B 47/105*** (2020.01); *F21Y 2115/10* (2016.08); *G06F 3/04883* (2013.01); *G06K 9/00335* (2013.01); *G06K 9/00791* (2013.01); *G06K 9/00845* (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC B60Q 3/76; B60Q 1/1423; B60Q 3/72; H05B 47/105; F21V 5/04; F21V 14/04; G06K 9/00791; G06K 9/00892; G06K 9/00335; G06K 9/00845; G06F 3/04883; F21Y 2115/10; H04N 7/181
See application file for complete search history.

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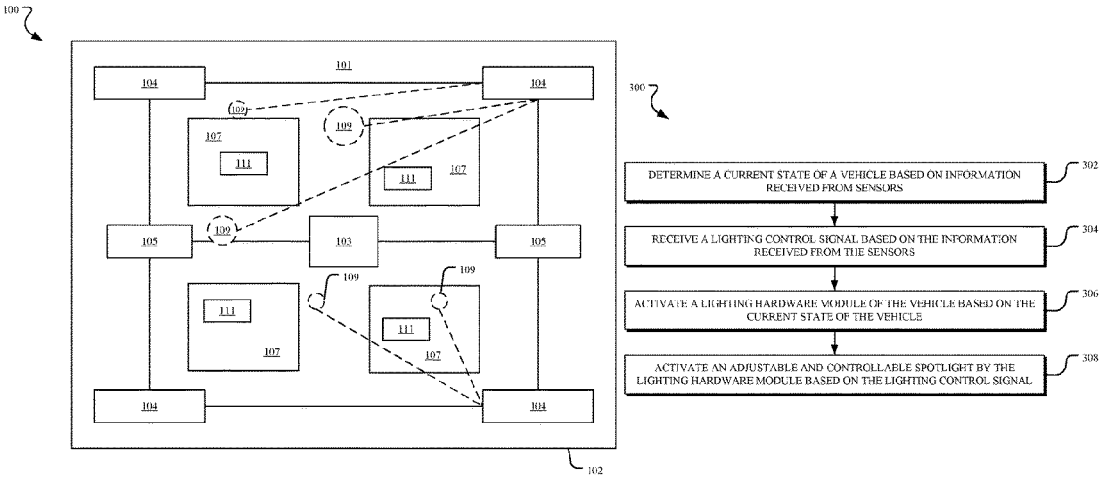
(57) **ABSTRACT**

A system includes a processor and a non-transitory computer-readable medium storing instructions that, when executed by the processor, cause the processor to perform operations including determining a current state of a vehicle, the current state determined based on information from sensors, receiving a lighting control signal based on the information received from the sensors, and activating an adjustable and controllable spotlight based on the lighting control signal.

20 Claims, 8 Drawing Sheets



Related U.S. Application Data

(60) Provisional application No. 62/350,827, filed on Jun. 16, 2016, provisional application No. 62/261,772, filed on Dec. 1, 2015.

(51) **Int. Cl.**

F21Y 115/10	(2016.01)
H04N 7/18	(2006.01)
G06F 3/0488	(2013.01)

(52) **U.S. Cl.**

CPC *G06K 9/00892* (2013.01); *H04N 7/181* (2013.01)

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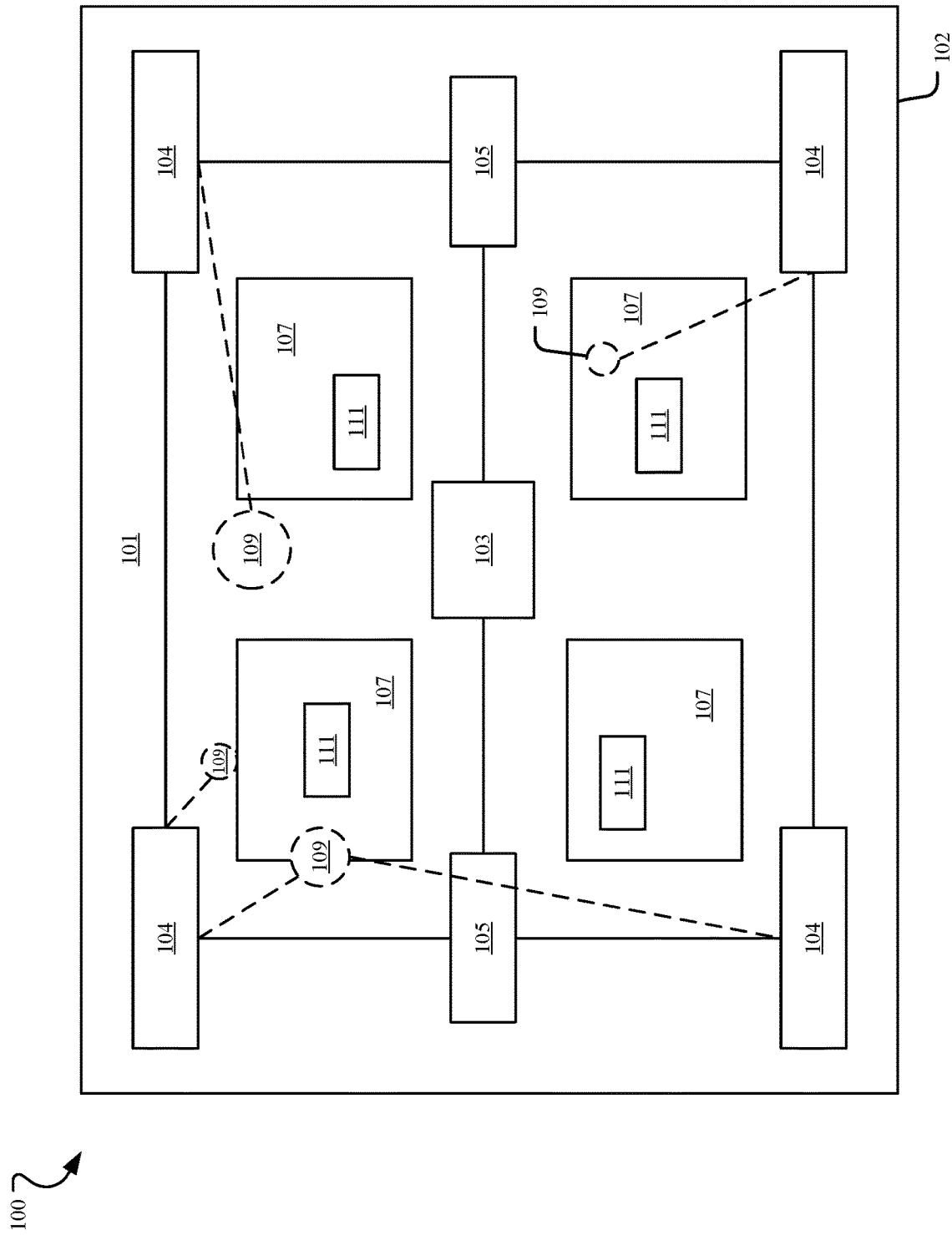

FIG. 1A

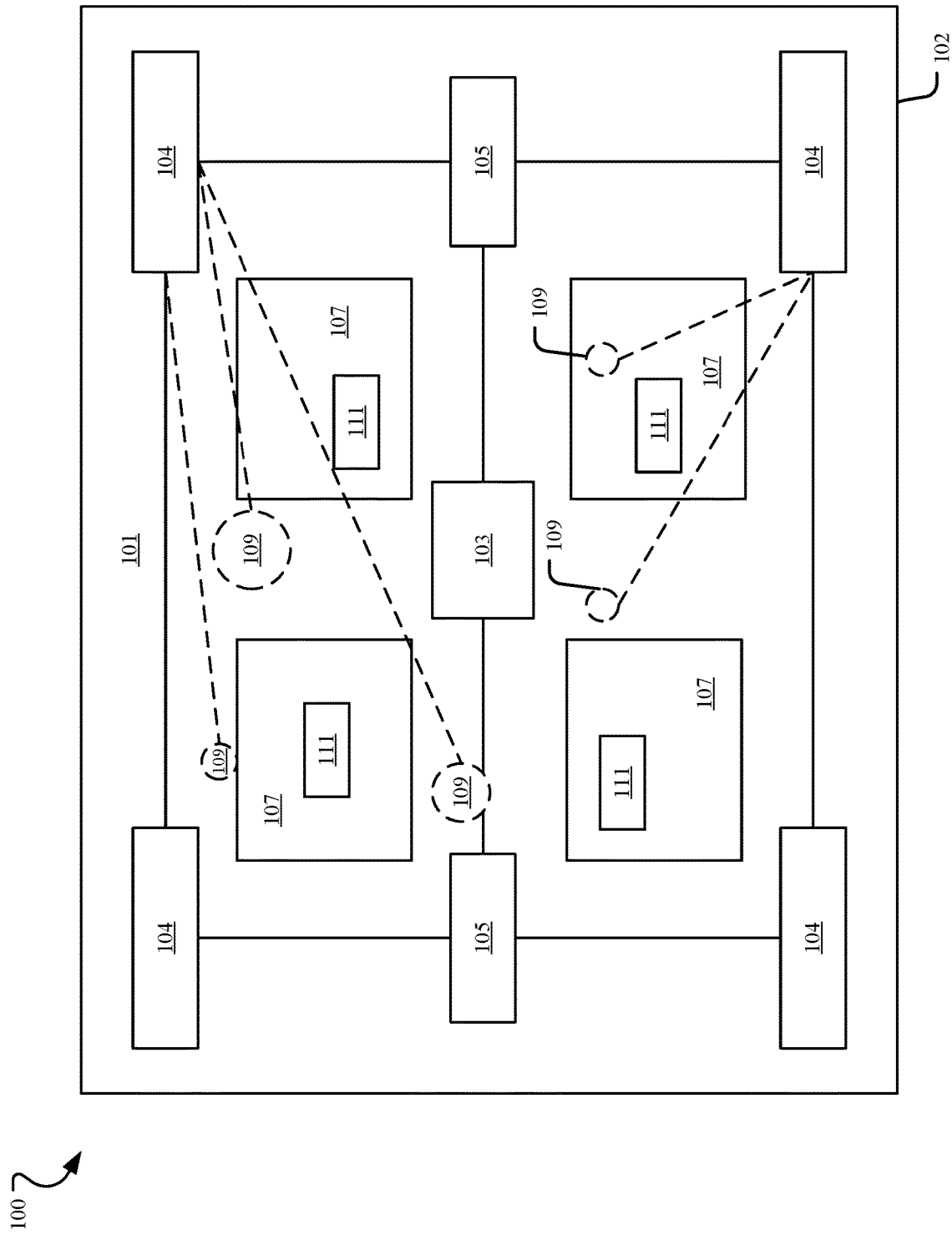

FIG. 1B

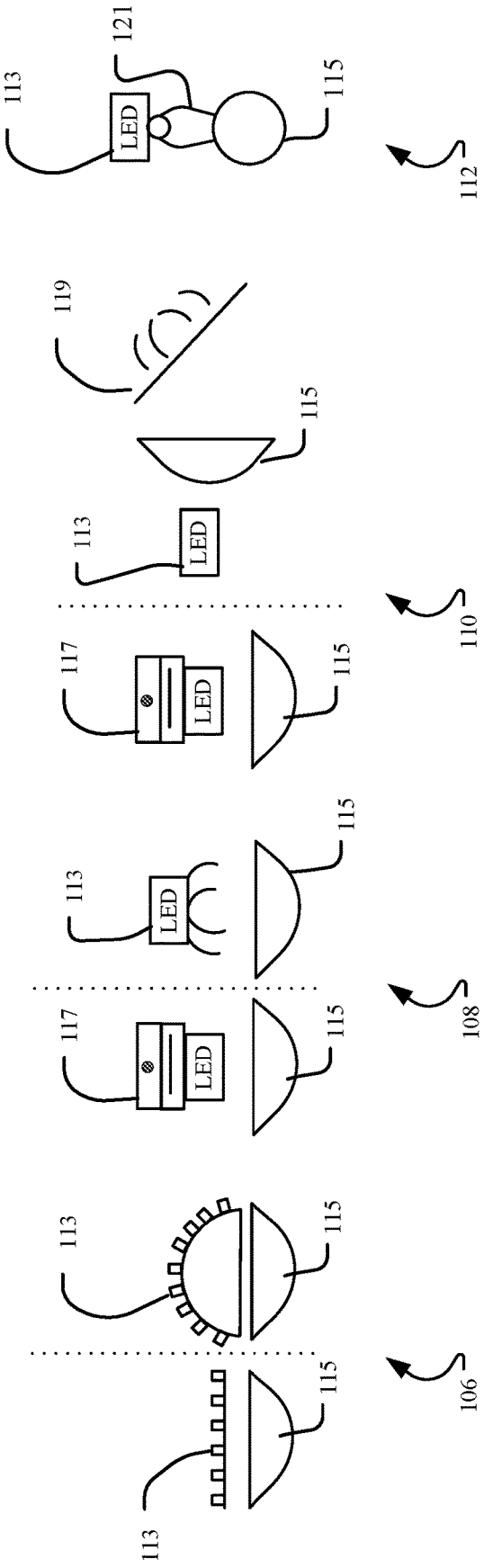
113
LED
121
115
112
119
115
113
LED
110
117
LED
115
113
LED
115
108
117
LED
115
113
115
106

FIG. 1C

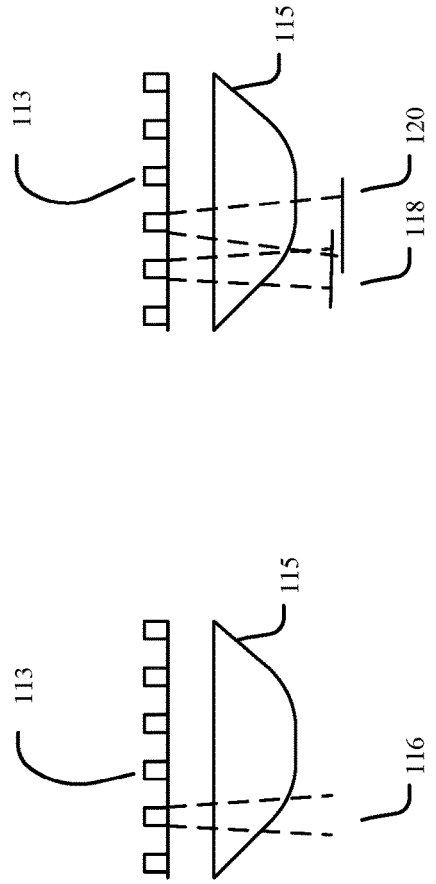
113
115
120
118
113
115
116
113
115
114

FIG. 1D

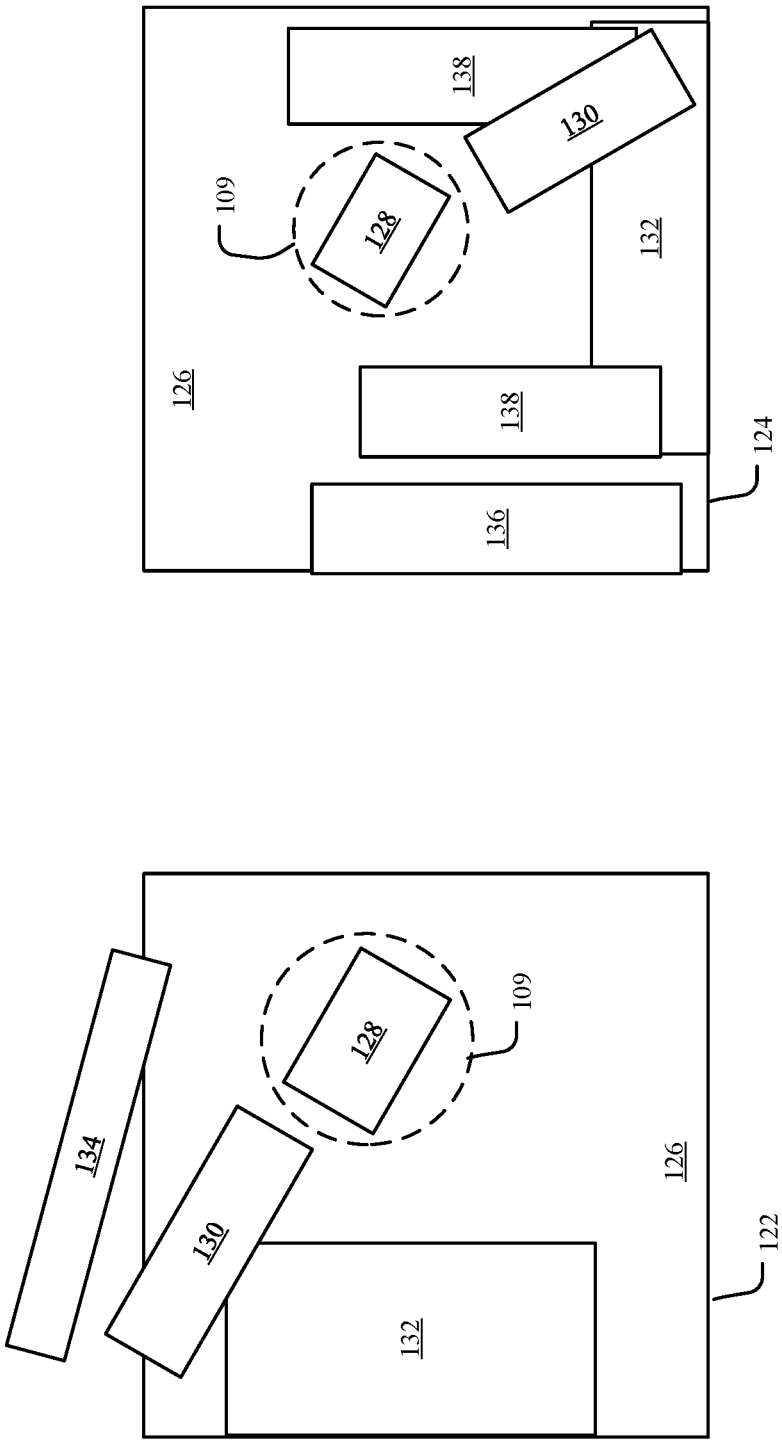

FIG. 1E

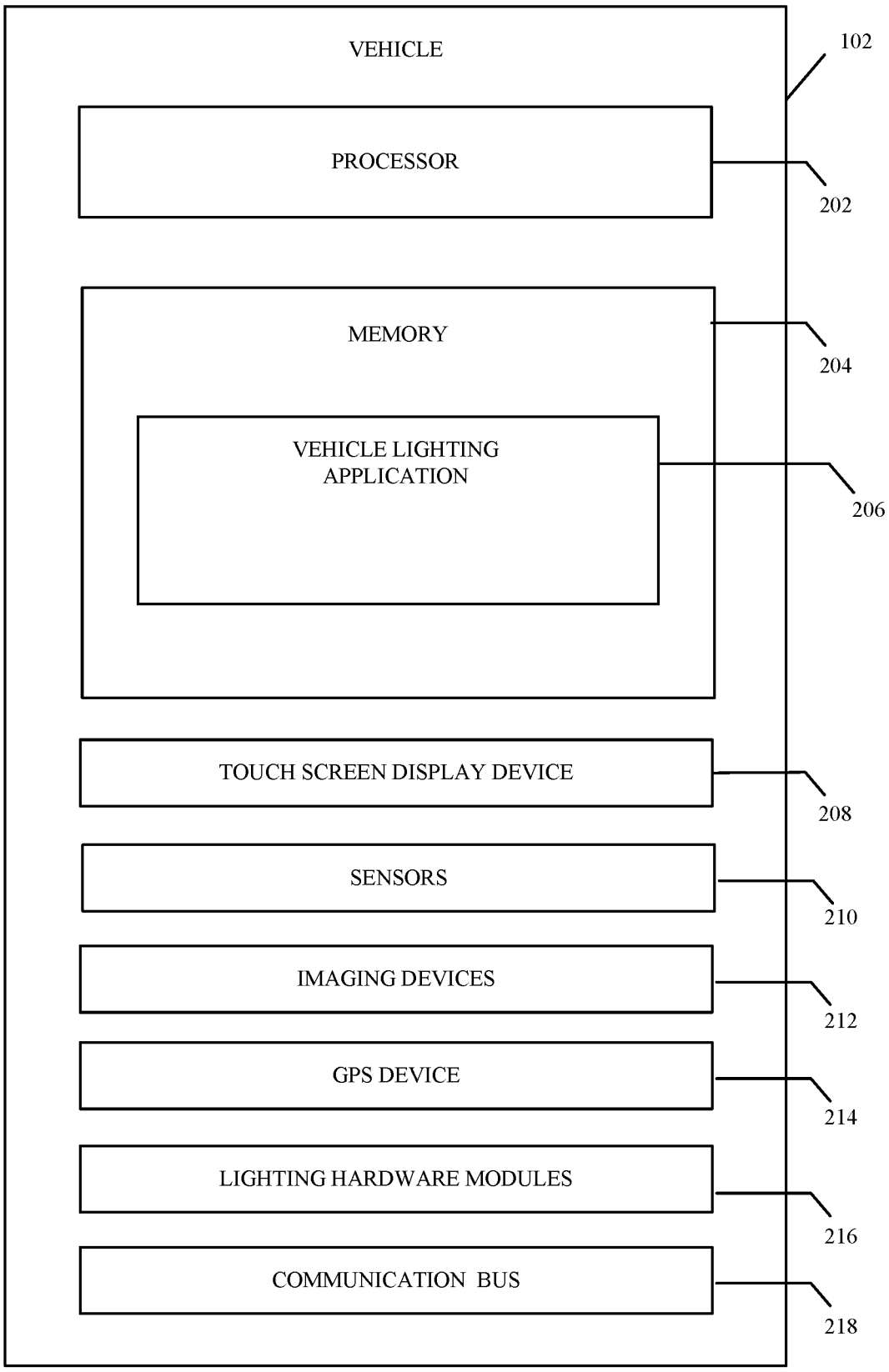
VEHICLE
102
PROCESSOR
202
MEMORY
204
VEHICLE LIGHTING APPLICATION
206
TOUCH SCREEN DISPLAY DEVICE
208
SENSORS
210
IMAGING DEVICES
212
GPS DEVICE
214
LIGHTING HARDWARE MODULES
216
COMMUNICATION BUS
218

FIG. 2

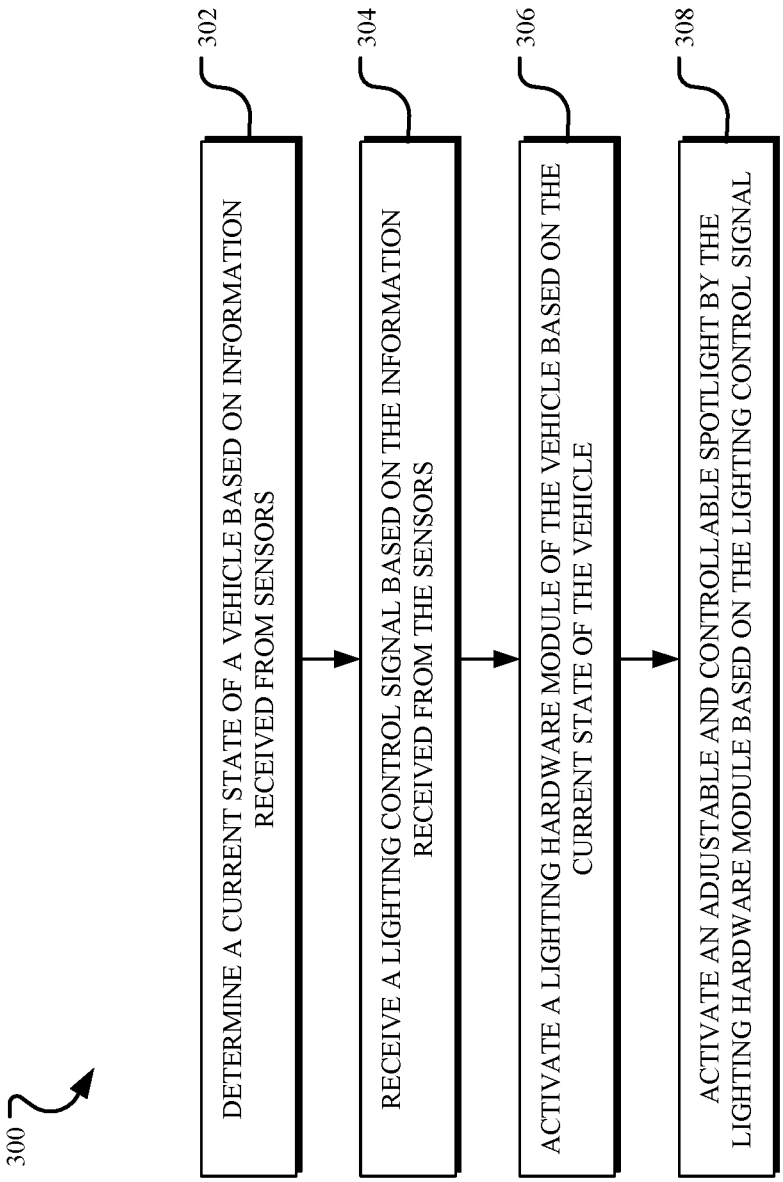
300
302
DETERMINE A CURRENT STATE OF A VEHICLE BASED ON INFORMATION RECEIVED FROM SENSORS
304
RECEIVE A LIGHTING CONTROL SIGNAL BASED ON THE INFORMATION RECEIVED FROM THE SENSORS
306
ACTIVATE A LIGHTING HARDWARE MODULE OF THE VEHICLE BASED ON THE CURRENT STATE OF THE VEHICLE
308
ACTIVATE AN ADJUSTABLE AND CONTROLLABLE SPOTLIGHT BY THE LIGHTING HARDWARE MODULE BASED ON THE LIGHTING CONTROL SIGNAL

FIG. 3

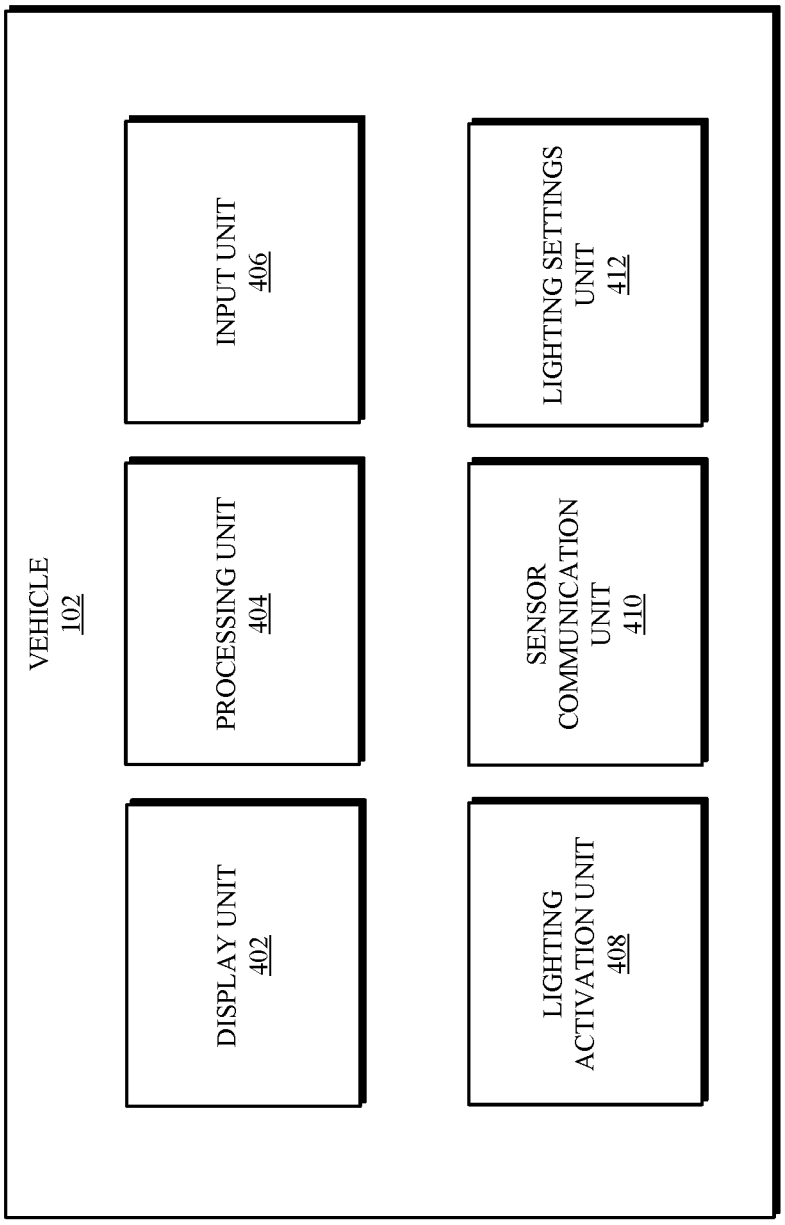
VEHICLE
102
DISPLAY UNIT
402
PROCESSING UNIT
404
INPUT UNIT
406
LIGHTING ACTIVATION UNIT
408
SENSOR COMMUNICATION UNIT
410
LIGHTING SETTINGS UNIT
412

FIG. 4

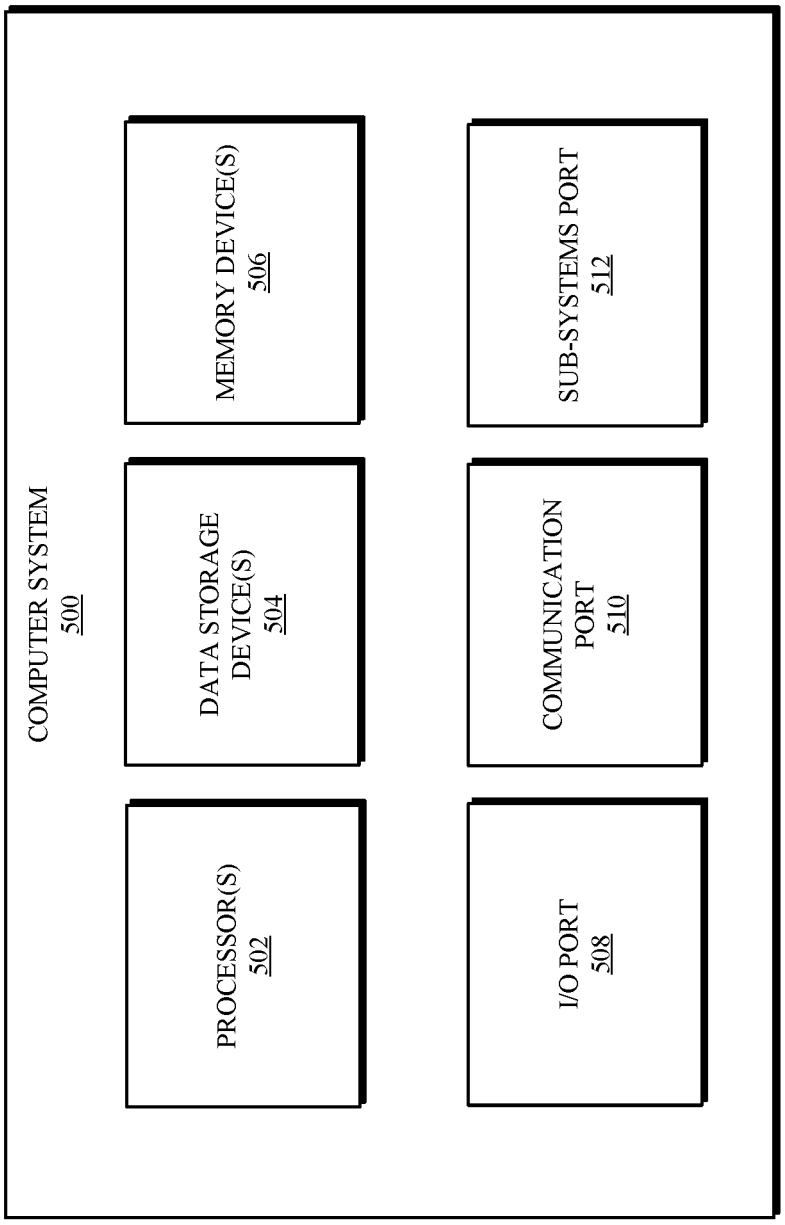
COMPUTER SYSTEM
500
PROCESSOR(S)
502
DATA STORAGE DEVICE(S)
504
MEMORY DEVICE(S)
506
I/O PORT
508
COMMUNICATION PORT
510
SUB-SYSTEMS PORT
512

FIG. 5

SYSTEM AND METHOD FOR ADJUSTABLE LIGHTING BASED ON OCCUPANT AND OBJECT IDENTIFICATION IN A VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 15/366,733 filed Dec. 1, 2016, which is related to and claims priority under 35 U.S.C. § 119(e) to U.S. Patent Application No. 62/350,827, filed Jun. 16, 2016, entitled "SYSTEM AND METHOD FOR ADJUSTABLE LIGHTING" and U.S. Patent Application No. 62/261,772, filed Dec. 1, 2015, entitled "SYSTEM AND METHOD FOR ADJUSTABLE LIGHTING," the entire contents of both are incorporated herein by reference.

FIELD

The described embodiments relate generally to a lighting environment. More particularly, the embodiments relate to adjustable and dynamic lighting within a lighting environment.

BACKGROUND

Conventional vehicle interior lights are static and typically vehicle occupants have to control the lights using a switch or a physical button. A conventional vehicle interior light may only illuminate a limited area while failing to illuminate large swaths of the interior of the vehicle. As an example, the vehicle occupant may be attempting to find an object dropped onto the floor of the vehicle at night. When the occupant turns on a light mounted on the roof of the vehicle, the light may not be helpful because the occupant's body may create a shadow or the light may not illuminate a correct location within the vehicle. Objects within the vehicle also may be difficult to view based on limited lighting options in the interior of the vehicle. In short, a vehicle with conventional lighting would benefit from many improvements.

SUMMARY

A system includes a vehicle with a computing device and lighting hardware modules. Briefly described, and according to one embodiment, aspects of the present disclosure generally relate to systems and methods for providing adjustable lighting that utilizes sensors and imaging devices of the vehicle to intelligently illuminate a particular object, location, or zone within an interior of the vehicle.

According to one embodiment, a system includes a processor and a non-transitory computer-readable medium storing instructions that, when executed by the processor, cause the processor to perform operations including determining a current state of a vehicle, the current state determined based on information from sensors, receiving a lighting control signal based on the information received from the sensors, and activating an adjustable and controllable spotlight based on the lighting control signal.

According to a further embodiment, a method includes determining, by a processor, a current state of a vehicle, the current state determined based on information from sensors, receiving, by the processor, a lighting control signal based on the information received from the sensors, and activating, by the processor, an adjustable and controllable time multiplexed spotlight based on the lighting control signal.

According to another embodiment, an apparatus includes a processor to determine a current state of a vehicle, the current state determined based on information from sensors, receive a lighting control signal based on the information received from the sensors, and activate N time multiplexed adjustable and controllable spotlights, each spotlight produced in a respective timeslot based on the lighting control signal.

These and other aspects, features, and benefits of the present disclosure will become apparent from the following detailed written description of the preferred embodiments and aspects taken in conjunction with the following drawings, although variations and modifications thereto may be effected without departing from the spirit and scope of the novel concepts of the disclosure.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings illustrate embodiments and/or aspects of the disclosure and, together with the written description, serve to explain the principles of the disclosure. Wherever possible, the same reference numbers are used throughout the drawings to refer to the same or like elements of an embodiment, and wherein:

FIGS. **1**A-**1**B illustrate block diagrams of a vehicle system according to example embodiments.

FIGS. **1**C-**1**D illustrate lighting hardware modules according to example embodiments.

FIG. **1**E illustrates an adjustable spotlight illuminating an object in two schematic drawings according to example embodiments.

FIG. **2** illustrates a block diagram of a vehicle computing system according to an example embodiment.

FIG. **3** illustrates a flowchart for activating and controlling adjustable lighting within a vehicle according to an example embodiment.

FIG. **4** illustrates a functional block diagram of an electronic device associated with the vehicle including operational units arranged to perform various operations of the presently disclosed technology.

FIG. **5** is an example computing system that may implement various systems and methods of the presently disclosed technology.

DETAILED DESCRIPTION

According to an example embodiment, an environment, such as a vehicle, includes a lighting system that determines objects, locations, and zones within the vehicle to illuminate while minimizing disturbance to vehicle occupants. The lighting system recognizes the objects, locations, and zones within the vehicle to be illuminated and responds to explicit requests or commands for illumination or anticipates implicit requests or commands for illumination. The lighting system automatically and dynamically adds and/or subtracts lighting to a location associated with an occupant, object, or zone.

In one embodiment, the lighting system provides adjustable spotlights that receive signals from or otherwise communicate with sensors and imaging devices of the vehicle to intelligently illuminate a particular object, location, or zone within an interior of the vehicle. In another embodiment, the lighting system that provides the adjustable spotlights includes mechanisms to respond to explicit and implicit commands from occupants of the vehicle such as verbal commands, gesture-based commands, and touch-based commands.

In an embodiment, the lighting system may include lighting hardware modules for activating and controlling the adjustable spotlights. The lighting hardware module may include a light emitting diode (LED) array, a lens, a translation stage, a moving mirror, and an optical fiber bundle. The lighting hardware module may provide an adjustable focal length and adaptive optics. In a further embodiment, the lighting hardware module may be a lighting source such as a liquid crystal display, an organic light emitting diode (OLED) display, a LED array, a projection display, or another pre-defined lighting panel. The projection display may be based on one of an LED digital light processing (DLP) light modulator, a micro-LED array, a laser scanner, and an LED liquid crystal (LC) light modulator, among others.

As an example, when an object is dropped onto a floor of the vehicle, the lighting system may automatically illuminate the dropped object and track a hand of the occupant as the occupant reaches for the object.

As another example, if an occupant is located in a rear zone of the vehicle and is illuminated by an adjustable spotlight, the lighting system may detect that the occupant is closing their eyes and drifting to sleep, e.g., the system may monitor a baby or toddler in a safety seat that is falling asleep. The lighting system may automatically and gradually turn the adjustable spotlight off to not disturb the occupant.

As a further example, an occupant may be located in a front zone of the vehicle while the vehicle is autonomously traveling from a first location to a second location at night. As the vehicle begins to approach the destination, the vehicle may automatically and gradually turn an adjustable spotlight on to gradually wake the occupant of the vehicle.

As an additional example, an occupant may be located in a rear zone of the vehicle while the vehicle is traveling from a first location to a second location. The lighting system may be providing soft lighting above a seat of the occupant. The lighting may be based on where the occupant is sitting, where the occupant is looking, and other factors such as ambient light. The lighting system may detect that the occupant is closing their eyes and drifting to sleep. The lighting system may automatically turn the lighting off.

In some embodiments, lighting may be location based. As an example, in a location known to the vehicle, and where illumination has been previously requested, the vehicle may illuminate all zones within the vehicle. In addition, in a location known to the vehicle and previously associated with storage lighting or otherwise associated with storage lighting, the vehicle may illuminate a storage area of the vehicle. In contrast, in a location unknown to the vehicle, the vehicle may not illuminate a storage area of the vehicle.

The vehicle and the lighting system may also accept a request or command such as gestures captured by imaging devices or touch screens, voice commands captured by microphones, and touch commands received by a touch screen. The lighting system responds to both explicit and implicit commands and controls lighting hardware modules based on the explicit and implicit commands. When an occupant enters the vehicle, the vehicle may determine that the occupant is a known occupant and activate the lighting hardware modules based on lighting personal profile settings associated with the occupant. In particular, this particular occupant may desire that the lighting hardware modules provide soft lighting in the front seats of the vehicle while not providing any lighting to a rear portion of the vehicle. After entering the vehicle and sitting in a seat in the front of the vehicle, the occupant may accidentally drop their mobile computing device onto the floor. The lighting system may automatically illuminate the floor and track the occupant's eyes and/or hands as they reach for the mobile computing device.

In another example, the lighting system may automatically detect that the occupant placed a briefcase, handbag, gym bag, or the like into the rear portion of the vehicle and gently laid the bag onto the floor. Over time, the vehicle may learn that the occupant usually places their bag onto the floor. The lighting system performs machine learning to detect placement of this bag, and does not illuminate it.

In another example, the vehicle may automatically detect that the occupant has opened a book or a newspaper, and thus intends to read the book or newspaper. The vehicle may have a database of objects to be illuminated that are detectable, such as the book or newspaper. Over time, the vehicle may learn that the occupant usually reads while the vehicle is in motion and the lighting system may provide task lighting onto pages of the book or newspaper.

In an additional example, the vehicle may learn over time that a child is seated in a child seat located in a rear zone of the vehicle. A parent of the child may help get the child seated and secured in the child seat each morning, for example, and the lighting system may provide a soft spotlight onto the child seat in the rear zone of the vehicle.

In a further example, a passenger unknown to the vehicle, but a guest of the occupant, may enter the vehicle and sit in a rear portion of the vehicle. The passenger may be previously unknown to the vehicle, but known to the occupant. The passenger of the occupant may want to read a map. A known occupant or the unknown passenger may provide an audible command. For example, either may state "vehicle please turn on the lights" and upon recognition of the verbal command, the vehicle may activate the lights in a rear portion of the vehicle.

While discussed in the context of a vehicle, the system may also be useful for residential building lighting, office lighting, commercial building lighting, or any other dynamic lighting environments.

The vehicle and/or a mobile computing device in communication with the vehicle may obtain biometric attributes of a person or occupant, and compare those biometric attributes with stored biometric attributes, using sensors and/or cameras or other imaging devices. The biometric attributes may be stored in memory of the mobile computing device and/or memory of the vehicle. The biometric attributes may be obtained and authenticated when the occupant approaches the vehicle and/or when the occupant is located within the vehicle. For example, the vehicle may determine that the occupant and/or a known mobile computing device is within a particular proximity of the vehicle. When a person has authenticated biometric attributes, the vehicle may illuminate lights within the vehicle when the mobile computing device is within the particular proximity of the vehicle. The lights may illuminate particular locations, objects (e.g., a seat), or zones. In certain instances, the vehicle may illuminate a particular zone or zones based on a location of the vehicle.

In an exemplary embodiment, seating arrangements within the vehicle may be rearranged and a seat may be moved from one location to another location. A seat may be rearranged from facing a front of the vehicle to a rear of the vehicle or from facing one side of the vehicle to another side of the vehicle. The vehicle may determine that the occupant has adjusted their seat and may illuminate lights appropriately. In certain instances, the vehicle may switch from illuminating a first particular zone or zones to a second particular zone or zones, or may switch from illuminating a

first particular location or locations to a second particular location or locations within the vehicle.

In a further embodiment, the vehicle may determine that the mobile computing device is within the vehicle or that a particular occupant is within the vehicle and set vehicle personal preferences. According to an example embodiment, the vehicle personal preferences may be associated with lighting profile preferences, seating position, seat heating, seat cooling, steering wheel heating/cooling, and localized climate controls. The lighting system may automatically illuminate adjustable spotlights for a particular person sitting in a particular seat.

Users can benefit from use of vehicle personal preferences and personal data provided by the mobile computing device when operating the vehicle. For example, the personal data can be used to provide the vehicle with lighting profile preferences, media, contact lists, navigation locations, navigation settings, energy usage settings, autonomous functionality settings, security settings, other climate control settings, other entertainment settings, and seat settings, among others. Accordingly, use of such personal data enables users to influence and control delivered content, and vehicle operation, among other things.

Users can selectively block use of, or access to, personal data. A system incorporating some or all of the technologies described herein can include hardware and/or software that prevents or blocks access to such personal data. For example, the system can allow users to "opt in" or "opt out" of participation in the collection of personal data or portions thereof. Also, users can select not to provide location information, or permit provision of general location information (e.g., a geographic region or zone), but not precise location information.

Entities responsible for the collection, analysis, disclosure, transfer, storage, or other use of such personal data should comply with established privacy policies and/or practices. Such entities should safeguard and secure access to such personal data and ensure that others with access to the personal data also comply. Such entities should implement privacy policies and practices that meet or exceed industry or governmental requirements for maintaining the privacy and security of personal data. For example, an entity should collect users' personal data for legitimate and reasonable uses, and not share or sell the data outside of those legitimate uses. Such collection should occur only after receiving the users' informed consent. Furthermore, third parties can evaluate these entities to certify their adherence to established privacy policies and practices.

According to exemplary embodiments, the vehicle may provide adjustable, controllable, and dynamic spotlighting that responds to explicit and implicit commands. The vehicle does not place a significant burden on the user and offers significant lighting enhancements and conveniences for occupants of the vehicle.

These and other embodiments are discussed below with reference to FIGS. **1A-5**. However, those skilled in the art will readily appreciate that the detailed description given herein with respect to these Figures is for explanatory purposes only and should not be construed as limiting.

FIG. **1A** illustrates a block diagram of a vehicle system **100** according to an example embodiment. The vehicle system **100** includes a vehicle **102** having a computing device **103** that is in communication with sensors **105** and lighting hardware modules **104**. The sensor **105** may include sensors and imaging devices, among other hardware devices for determining various attributes of the vehicle or occupants. The vehicle **102** may be a machine that transports people and/or cargo including a terrestrial motor vehicle, a watercraft, and an aircraft, among other vehicles. The vehicle **102** may include an engine or a motor such as an internal combustion engine, an electric motor, or a hybrid configuration.

As shown in FIG. **1A**, the vehicle **102** may include an environment **101** with zones **107** that may be illuminated by any given lighting hardware module **104** or combination of modules, and/or combination of modules and general wide area illumination. The entire area of the vehicle may be illuminable. There may be occupants **111** such as a person located in each zone **107**. The lighting hardware modules **104** may together create and control adjustable spotlights **109** illuminating particular locations and particular zones **107** within the vehicle. The adjustable spotlights **109** may have an adjustable shape, profile, position, intensity, size, and color, among other adjustable attributes.

As shown in FIG. **1B**, one lighting hardware module **104** may create and control adjustable spotlights **109** illuminating particular locations and/or particular zones **107** in the vehicle **102**. The lighting hardware module **104** may provide spotlights **109** that are time multiplexed or modulated in a number of different locations faster than a user may perceive. The lighting hardware module **104** may simultaneously produce N spotlights **109** having varied shapes, profiles, positions, intensities, sizes, and colors, among other adjustable attributes. As an example, the N spotlights **109** may be time multiplexed at a rate roughly greater than 200 Hz wherein each spotlight has a timeslot and each spotlight is produced in its respective timeslot.

A first spotlight **109** may be produced in a first location in a front left of the vehicle **102** near a first occupant **111** and a second spotlight **109** may be produced in a second location in a front right of the vehicle near a second occupant **111**. The first occupant **111** may be a driver of the vehicle **102** and the second occupant **111** may be a passenger of the vehicle. The first location and the second location may be simultaneously illuminated. In addition, the lighting for the second location and/or the first location may be turned on or off without affecting the lighting for the other location.

A third spotlight **109** may be produced in a third location in a back left of the vehicle **102** near a third occupant **111** and a fourth spotlight **109** may be produced in a fourth location in a back right of the vehicle **102** near a fourth occupant **111**. The single lighting hardware module **104** may provide the N adjustable spotlights that are time multiplexed.

There may be seats located in each zone **107** among other vehicle components such as a roof, windshields, dashboards, windows, tables, armrests, and footrests, among other components.

The vehicle **102** and the computing device **103** may communicate in various ways or combinations thereof. The vehicle **102** and the computing device **103** may use wired communication methods and Bluetooth, WiFi, or other such short range wireless methods.

The vehicle **102** and the computing device **103** may communicate using a cellular communications network or another communications network. Accordingly, communication may involve the Internet, an intranet, a cellular communications network, a WiFi network, a packet network, a short-range wireless network, or another wired and/or wireless communication network or a combination of any of the foregoing. As an example, the vehicle **102** and the computing device **103** may communicate data in packets, messages, or other communications using a common protocol, e.g., Hypertext Transfer Protocol (HTTP) and/or Hypertext Transfer Protocol Secure (HTTPS). The vehicle

102 and/or the computing device 103 may communicate with other optional server computing devices associated with the vehicle system 100.

The vehicle 102 and/or the computing device 103 may also optionally include Bluetooth® Low Energy (BLE, Bluetooth® LE, Bluetooth® Smart) functionality based on the Bluetooth 4.0 specification or another specification. In addition, the vehicle 102 may include a beacon. According to an example embodiment, the vehicle 102 and the computing device 103 are paired and communicate wirelessly using a short range wireless network, e.g., Bluetooth® (IEEE Standard 802.15). The short range wireless network may be a wireless personal area network (WPAN).

In another example, the vehicle 102 may optionally create a personal area network and/or a mesh network for communicating with the computing device 103. Additionally, the vehicle 102 and the computing device 103 may communicate using Zigbee®, Wi-Fi, near field magnetic inductance, sonic (sound) waves, ultrasound waves, and/or infrared (light) waves, among others.

FIGS. 1C-1D illustrate seven representative section views of lighting hardware modules of the vehicle system 100 according to various possible example embodiments. Each of the lighting hardware modules shown in FIGS. 1C-1D may be used to provide and control adjustable spotlights 109 having a tunable spot size, location, intensity, shape, and color, alone or in various combinations. The lighting hardware modules may be positioned, in one embodiment, sufficiently to individually or in some combination, provide spot or task illumination in the interior of the vehicle 102.

As shown in FIG. 1C, there is a first example lighting hardware module 106 associated with the vehicle system 100 that includes a one dimensional (1D) or two-dimensional (2D) light emitting diode (LED) or micro-LED array 113 that is located on a planar surface or a two-dimensional curved surface that may be attached to or otherwise operably coupled with a lens 115. The array of LEDs 113 may have a particular or variable offset (among discrete LEDs of the array) and may be located on a planar surface or a compound curve surface. In addition, each LED, whether a single LED or member of an array of LEDs, may be a white LED, an RGB LED, or color LED. The lens 115 may be a varioptic lens for varying focus. The position and shape of the spotlight 109 may be tuned, adjusted, and modified by turning on and off individual LEDs (e.g., individually controlling each LED or a group of LEDs) within the array 113.

A second example lighting hardware module 108 associated with the vehicle system 100 includes an LED (or other lighting element) 113 coupled with a translation stage 117. The LED element may be a single LED, an LED array 113 as described in the first example lighting hardware module, and may include a lens 115 as described in the first example lighting hardware module. The array of LEDs 113 may be mounted on a uni-directional, a bi-directional, or a tri-directional translation stage 117. The stage 117 is under processor control to move the stage position (and coupled LED element) to provide spotlighting, task-lighting, and wide area lighting. The position and shape of the spotlight 109 can be tuned, adjusted, and modified by translating the LED array 113 and/or turning on and off individual LEDs within the array.

A third example lighting hardware module 110 associated with the vehicle system 100 includes various possible LED elements 113 and a translation stage 117, such as those described in the first example lighting hardware module and the second example lighting hardware module, or a moving mirror 119 instead of or in addition to the stage 117 operably coupled with a varioptic lens 115. As a result, the third example lighting hardware module 110 provides an adjustable focal length. The varioptic lens 115 allows the spotlight 109 to focus on objects that are located near the lighting hardware module and at more distant locations from the lighting hardware module. The third example lighting hardware module 110 provides a spotlight 109 that can be tuned, adjusted, and modified as in the first example lighting hardware module and the second example lighting hardware module. In addition, the third example lighting hardware module 108 may provide collimated light and adjust the spotlight beam collimation.

A fourth example lighting hardware module 112 associated with the vehicle system 100 includes the 2D LED array 113 as described in the first, second, and third lighting hardware module that is connected to an optical fiber bundle taper 121, and the lens 115 as described in the first, second, and third lighting hardware modules. The fiber bundle taper 121 is used to combine the outputs of multiple LEDs of the LED array 113 and may be attached to the LED array and/or the lens using transparent glue or bonding materials.

The LED array 113 of the first, second, third, and fourth lighting hardware modules may shine light onto the lens 115, which is a tunable molecular liquid-crystal lens. The focal length may be controlled by adjusting an orientation of liquid crystals associated with the lens. The lens 115 enables tuning the shape, profile, and position of the spotlight 109. The LEDs may be small, e.g., approximately 10 μm micro-LEDs. This may enable the fill factor of the LED array 113 to be low so that the LED array appears transparent. If the liquid crystal lens is flat, it also may appear as transparent. Therefore, the adjustable spotlight 109 may be essentially invisible or nearly invisible so that it may be integrated into a transparent glass panel of the vehicle 102. This may allow the first, second, third, and fourth lighting hardware modules to be integrated into glass of the vehicle 102 or any other location in the vehicle including the frame of the vehicle 102.

As an example, the lighting hardware module 104 may be embedded within a roof of the vehicle, a window portion of the vehicle, a headrest of the vehicle, a floor of the vehicle, a seat of the vehicle, a support beam of the vehicle, and/or in other locations. The vehicle 102 may include lighting hardware modules 104 mounted within the roof to illuminate directly onto seats, lighting hardware modules 104 mounted on or near the floor of the vehicle to illuminate footwells, and lighting hardware modules 104 mounted to support beams of the vehicle to illuminate door handles.

One lighting hardware module 104 may be used to illuminate more than one occupant or generate more than one adjustable spotlight 109. As an example, the lighting hardware module 104 located in a front of the vehicle 102 may modulate between two different occupants 111 or zones 107 or between two adjustable spotlights 109 to generate the two adjustable spotlights. A first lighting hardware module 104 may simultaneously illuminate a left-front side of the vehicle and a right-front side of the vehicle. In addition, a second lighting hardware module 104 may provide additional lighting for the left-front side of the vehicle. The left-front side of the vehicle may be brighter or may have a larger spotlight than the right-front side of the vehicle.

FIG. 1D shows three different examples of a 2D LED array of a lighting hardware module. In one lighting hardware module, a third LED 114 of the 2D array 113 is illuminated, shining light onto the lens 115. In another lighting hardware module, a second LED 116 of the 2D array 113 is illuminated, shining light onto the lens 115. In

an additional lighting hardware module, a second LED **118** of the 2D array **113** and a third LED **120** of the 2D array **113** are illuminated, shining light onto the lens **115** and providing an overlapping illumination.

FIG. **1**E shows two schematic drawings **122**, **124** of an example of an adjustable spotlight **109** illuminating an object **128** located on a floor **126** of the vehicle **102**.

As shown in drawing **122**, an occupant **111** may have opened a door **134** of the vehicle **102** to find a misplaced object **128**. The sensors **105** determine that the object **128** has fallen onto the floor or footwell **126** of the vehicle **102** below a seat **132** and the lighting hardware modules **104** automatically illuminate a location associated with the object **128** with an adjustable spotlight **109**. In this case, the vehicle **102** may determine that this object **128** is a foreign object not normally located in this particular location. The sensors **105** track the arm/hand **130** and gaze of the occupant **111** as the occupant picks up the object **128** on the floor **126** of the vehicle **102**. After the object **128** is picked up, the sensors **105** may detect the absence of the object, and may turn the adjustable spotlight **109** off after a particular period of time.

As shown in drawing **124**, an occupant **111** may be seated on a seat **132** within the vehicle **102** and may have dropped an object **128** onto the floor **126** and to the right of a vehicle console **136**. The sensors **105** determine that the object **128** has fallen onto the floor or footwell **126** of the vehicle below the seat **132** and the lighting hardware modules **104** automatically illuminate a location associated with the object with an adjustable spotlight **109**. In this case, the vehicle **102** may determine that this object **128** is a foreign object not normally located in this particular location. The sensors **105** track the arm/hand **130**, the leg/foot **138**, and the gaze of the occupant **111** as the occupant picks up the object **128** on the floor **126** of the vehicle **102**. After the object **128** is picked up, the sensors **105** may detect the absence of the object, and may turn the adjustable spotlight **109** off after the particular period of time.

FIGS. **1**A, **1**B, and **2** illustrate a block diagram of the vehicle **102** according to an example embodiment. The vehicle **102** may include a computing device having a hardware component including a processor **202** and memory **204**, such as a vehicle onboard computer or a dedicated electronic device having a processor and memory. The processors **202** process machine/computer-readable executable instructions and data, and the memory **204** stores machine/computer-readable executable instructions and data including applications, such as a vehicle lighting application **206**. The processor **202** and memory **204** are hardware. The processor **202** may be a hardware processing unit. In one embodiment, the processor **202** includes a secure enclave processor (SEP). The SEP stores and protects information used for identifying known mobile computing devices, biometric information, and lighting preference profiles for occupants, among other information. The memory **204** includes random access memory (RAM) and non-transitory memory, e.g., a non-transitory computer-readable storage medium such as flash storages or hard drives. The non-transitory memory may include any tangible computer-readable medium including, for example, magnetic and/or optical disks, flash drives, and the like.

The vehicle **102** further can include touch screen display devices **208**, such as a liquid-crystal display (LCD) for receiving input and displaying output, sensors **210**, cameras or imaging devices **212**, a global positioning system (GPS) device **214**, lighting hardware modules **216**, and a communication bus **218**. The vehicle **102** may include other wireless communication devices for communicating including a wireless transceiver, a cellular transceiver, a Bluetooth transceiver, and others.

The touch screen display devices **208** may be located on an exterior of the vehicle and/or an interior of the vehicle for receiving input and displaying output including lighting control buttons. The lighting control buttons may be provided by a user interface of the vehicle **102** and/or a user interface of a mobile computing device in communication with the vehicle **102**. For example, the touch screens **208** may be located within an interior of the vehicle. The sensors **210** and the imaging devices **212** may be used for biometric identification and authentication. The sensors **210** may be located on the exterior of the vehicle and/or the interior of the vehicle and include fingerprint sensors, iris recognition devices, eye vein verification devices, microphones, seat pressure sensors, load or weight sensors (e.g., a strain gauge), pressure sensors, ambient light sensors (ALS), electrocardiogram (ECG) sensors, and infrared (IR) antennas, among others. The sensors **210** may be coupled with the processor **202** for obtaining biometric information.

The imaging devices **212** may be coupled with the processor **202** for facial recognition. The imaging devices **212** include high-definition cameras and may be used to determine two-dimensional images and/or three-dimensional images including a two-dimensional image of a face or a three-dimensional image of a face, a height of a person, a body shape of a person, or a gait of a person. The imaging devices **212** may be located on an exterior of the vehicle and/or an interior of the vehicle. In one example, each seat within the vehicle may include imaging devices to capture a face of a passenger sitting in that particular seat. The touch screen display devices **208** and/or the imaging devices **212** may be used to receive lighting control input regarding an object, zone, location, or emission area and gestures, such as a pinch, pull, zoom, or a gesture pointing to an object, zone, location, or emission area, among other gestures. The microphones may be used to receive verbal commands such as lighting control related to an object, location, zone, or emission area.

The global positioning system device **214** may receive GPS signals and thereby determine a current location of the vehicle **102**. The lighting hardware modules **216** may include one first lighting hardware module located in a front-right portion of the vehicle **102**, one second lighting hardware module located in a front-left portion of the vehicle **102**, one third lighting hardware module located in a rear-right portion of the vehicle **102**, and a fourth lighting hardware module located in a rear-left portion of the vehicle **102**. However, the lighting hardware modules **216** may be arranged in other ways such that the lighting hardware modules **216** eliminate shadowing of objects and/or occupants and can properly illuminate locations and zones within the vehicle. The vehicle **102** may include more than four lighting hardware modules **216** or less than four lighting hardware modules **216**.

The vehicle **102** may be in communication with other computing devices such as mobile computing devices carried by occupants of the vehicle. The mobile computing device may be a computer having a processor and memory, such as a laptop, desktop, tablet computer, mobile computing device (e.g., a smartphone), a wearable device (e.g., a watch), or a dedicated electronic device having a processor and memory. The processors process machine/computer-readable executable instructions and data, and the memory stores machine/computer-readable executable instructions and data including applications, such as a client application

that communicates with the vehicle lighting application **206**. The processor and memory are hardware. The processor may be a hardware processing unit. In one embodiment, the processor includes a secure enclave processor (SEP). The SEP stores and protects biometric information and lighting preference profile information, among other information. The memory includes random access memory (RAM) and non-transitory memory, e.g., a non-transitory computer-readable storage medium such as flash storages or hard drives. The non-transitory memory may include any tangible computer-readable medium including, for example, magnetic and/or optical disks, flash drives, and the like.

The mobile computing device further includes a touch screen display device such as a liquid-crystal display (LCD) to receive input and display output, sensors such as an ambient light sensor, an accelerometer, a gyroscopic sensor, microphones, a magnetometer, a barometer, and a fingerprint sensor, cameras or imaging devices, a GPS device, and a communication bus. The mobile computing device may include other wireless communication devices for communicating including a wireless transceiver, a cellular transceiver, a Bluetooth transceiver, and others.

The touch screen display device receives input and displays output. The sensors and the imaging devices may be used for biometric identification and authentication. The sensors may be in communication with the processor **202** for obtaining biometric information. The imaging devices may include high-definition cameras and may be used to determine two-dimensional images and/or three-dimensional images including a two-dimensional image of a face or a three-dimensional image of a face, a height of a person, a body shape of a person, or a gait of a person. The touch screen display device and/or the imaging devices may be used to receive gestures. They also may be used to receive verbal commands. The global positioning system device may continually determine a current location of the mobile computing device.

The vehicle lighting application **206** may have a component of an application and/or service executable by the vehicle **102** and/or the mobile computing device. For example, the vehicle lighting application **206** may be a single unit of deployable executable code. According to one aspect, the vehicle lighting application **206** may be a web application, a native application, and/or a mobile application (e.g., an app) downloaded from a digital distribution application platform that allows users to browse and download applications developed with mobile software development kits (SDKs).

As an example, the vehicle **102** may receive a communication from a known mobile computing device, determine, by a sensor **210**, biometric information associated with the known occupant, grant access to the vehicle **102**, and set vehicle personal preferences including lighting preferences based on the communication and the biometric information. The biometric information may be facial recognition information and/or another type of biometric information. The vehicle **102** may unlock doors and extend welcome functions including external lighting, internal lighting, cabin configuration, and other welcome functions. The vehicle may illuminate the external lighting and/or the internal lighting when the occupant **111** and/or the mobile computing device is a particular distance from the vehicle, e.g., one meter. The particular distance may be modified and may be based on a particular location of the vehicle **102**.

In another example, a person **111** may touch a door handle or door of the vehicle **102** to provide the biometric authentication information. The door handle or the door may have a fingerprint sensor and/or other sensors for obtaining a fingerprint and/or other signals. The vehicle **102** may then compare the biometric information associated with the person with biometric attributes stored in memory **204** of the vehicle **102** and/or memory of the mobile computing device. The person may enter the vehicle **102** and sit in a driver seat or a passenger seat.

FIG. **3** illustrates a flowchart of a process **300** for activating and controlling adjustable lighting within a vehicle according to an example embodiment. The process **300** shown in FIG. **3** begins at operation **302**. In **302**, the vehicle **102** determines a current state of the vehicle based on information received from the sensors **210**, the imaging devices **212**, and the GPS device **214**. The current state of the vehicle **102** may include a current state of each zone **107** of the vehicle. The current state may be based on explicit commands and implicit commands in addition to lighting personal preferences of occupants **111** in the vehicle. The sensors **210** and imaging devices **212** may execute a feedback loop and continually determine whether objects are located in each zone **107** of the vehicle and determine whether any changes occur in the current state. Based on the feedback loop, the lighting hardware modules **216** may provide anticipatory lighting that dynamically and automatically adjusts to the determined changes.

In **304**, the lighting hardware modules **216** receive a lighting control signal from the vehicle **102** based on the information received from the sensors **210**, the imaging devices **212**, and the GPS device **214**. As an example, the sensors **210** and the imaging devices **212** may determine that a current state of the vehicle has changed in a zone **107** of the vehicle and lighting hardware modules **216** may be activated to illuminate an object, location, or zone in the vehicle.

After determining that the current state of the vehicle has changed in zones **107** of the vehicle, in **306**, the vehicle **102** activates lighting hardware modules **216** based on the current state of the vehicle as determined by the sensors **210**, the imaging devices **212**, and the GPS device **314**. The lighting hardware module may be one of the examples described with reference to FIG. **1**C. In particular, the lighting hardware module may include an LED array, a translation stage, and a lens. As an example, an occupant **111** may have approached the vehicle, entered the vehicle, and sat down in a seat. The vehicle **102** may illuminate a location associated with the seat. In another example, the sensors **210** and the imaging devices **212** may detect that the occupant **111** has opened a book. In another example, the sensors **210** and the imaging devices **212** may detect that an occupant **111** has fallen asleep or is resting. As another example, the sensors **210** and the imaging devices **212** may detect that a child **111** is crying. The sensors **210** and imaging devices **212** may detect that a heart rate of a passenger **111** is changing, may detect that eyes are closing, and may detect other changing biometric factors. In a further example, an occupant **111** may have exited the vehicle. The sensors **210** and imaging devices **212** may detect the absence of the occupant **111** and may deactivate the lighting hardware module **216** and turn off the lighting.

In **308**, the lighting hardware module **216** activates an adjustable and controllable spotlight **109** based on the lighting control signal. The adjustable and controllable spotlight **109** may be an adjustable and controllable time multiplexed spotlight or N time multiplexed spotlights, each spotlight produced in a respective timeslot based on the lighting control signal. Based on the examples described above, if the occupant **111** has sat down in the seat, the lighting

hardware module **216** may activate a spotlight that is based on the personal lighting preferences of the occupant. If the occupant **111** has fallen asleep or the occupant is crying and a spotlight is shining on the occupant, the lighting hardware module **216** may gradually turn the spotlight off. The adjustable and controllable spotlight **109** may be activated based on one of an explicit command and an implicit command. In other words, the lighting control signal may be based on one of the explicit command and the implicit command. The vehicle lighting application **206** may receive an explicit lighting command, and the explicit lighting command may be one of a gesture activated command, a voice activated command, and a touch command. In response to the command, the vehicle lighting application **206** activates the lighting hardware module **216** based on the explicit lighting command. The vehicle lighting application **206** also may receive an implicit command. The implicit command is based on a change in the current state. In response to the command, the vehicle lighting application **206** activates the lighting hardware module **216**. Based on the explicit command and/or the implicit command, the lighting hardware module **216** controls a shape, a profile, a position, an intensity, a size, and a color of illumination. In another example, the implicit command may be based on intent of an occupant **111** based on eyes of an occupant, a head of an occupant, a hand of an occupant, a body position of an occupant, and a gaze of an occupant as determined by the sensors **210** and the imaging devices **212**. The vehicle lighting application **206** may activate the lighting hardware module **216** based on the intent of the occupant **111** or the perceived intent of the occupant. The intent may be determined by determining a vector from a finger or hand from the occupant and/or a vector to the eyes of the occupant.

Turning to FIG. **4**, the vehicle **102** including operational units **402-412** arranged to perform various operations of the presently disclosed technology is shown. The operational units **402-412** may be provided by the vehicle lighting application **206** and may communicate with the mobile computing device. The operational units **402-412** of the vehicle **102** are implemented by hardware or a combination of hardware and software to carry out the principles of the present disclosure. It will be understood by persons of skill in the art that the operational units **402-412** described in FIG. **4** may be combined or separated into sub-blocks to implement the principles of the present disclosure. Therefore, the description herein supports any possible combination or separation or further definition of the operational units **402-412**.

In one implementation, the vehicle **102** includes a display unit **402** configured to display information, such as a graphical user interface, and a processing unit **404** in communication with the display unit **402** and an input unit **406** configured to receive data from input devices or systems. Various operations described herein may be implemented by the processing unit **404** using data received by the input unit **406** to output information for display using the display unit **402**.

Additionally, in one implementation, the vehicle **102** includes units implementing the operations described with respect to FIG. **3**. For example, the operations **302**, **304**, **306**, and **308** may be implemented by a lighting activation unit **408**, a sensor communication unit **410**, and a lighting settings unit **412**. The lighting activation unit **408**, the sensor communication unit **410**, and the lighting settings unit **412** may together activate and control the lighting hardware module **216** based on explicit and implicit lighting commands. As an example, the lighting activation unit **408** may include an explicit lighting command unit and an implicit lighting command unit.

The sensor communication unit **410** may include a biometric authentication unit that communicates with the sensors **210** and the imaging devices **212**. The biometric authentication unit may use a biometric matching engine for receiving biometric information from the sensors **210**, the imaging devices **212**, and comparing the biometric information with the information stored in the vehicle memory **204** and the memory in the processor **202**. The biometric authentication unit determines whether the biometric information matches known biometric information (e.g., comparing the representation of a face to known faces) and provides a determination of match or no match. Each known face may be first stored when an occupant **111** approaches and/or enters the vehicle **102** or at another time. The biometric authentication unit may make the determination based on a particular location of the vehicle. Based on the determination, the lighting settings unit **412** may determine whether there are personal lighting profile preferences associated with an occupant **111**.

The sensor communication unit **410** also may include an object authentication unit that communicates with the sensors **210** and the imaging devices **212**. The object authentication unit may use an object matching engine for receiving object information from the sensors **210**, the imaging devices **212**, and comparing the object information with the object information stored in the vehicle memory **204** and the memory in the processor **202**. The object authentication unit determines whether the object information matches known object information (e.g., comparing a representation of a book with a known representation of a book) and provides a determination of match or no match. As a result, the object authentication unit and the biometric authentication unit provide machine learning capabilities for the vehicle **102**.

Referring to FIG. **5**, a detailed description of an example computing system **500** having computing units that may implement various systems and methods discussed herein is provided. The computing system **500** may be applicable to the vehicle **102** and the mobile computing device and other computing or network devices. It will be appreciated that specific implementations of these devices may be of differing possible specific computing architectures not all of which are specifically discussed herein but will be understood by those of ordinary skill in the art.

The computer system **500** may be a computing system that is capable of executing a computer program product to execute a computer process. Data and program files may be input to the computer system **500**, which reads the files and executes the programs therein. Some of the elements of the computer system **500** are shown in FIG. **5**, including hardware processors **502**, data storage devices **504**, memory devices **506**, and/or ports **508-512**. Additionally, other elements that will be recognized by those skilled in the art may be included in the computing system **500** but are not explicitly depicted in FIG. **5** or discussed further herein. Various elements of the computer system **500** may communicate with one another by way of communication buses, point-to-point communication paths, or other communication means not explicitly depicted in FIG. **5**.

The processor **502** may include, for example, a central processing unit (CPU), a microprocessor, a microcontroller, a digital signal processor (DSP), and/or internal levels of cache. There may be processors **502**, such that the processor **502** comprises a single central-processing unit, or processing units capable of executing instructions and performing

operations in parallel with each other, commonly referred to as a parallel processing environment.

The computer system **500** may be a conventional computer, a distributed computer, or any other type of computer, such as external computers made available via a cloud computing architecture. The presently described technology is optionally implemented in software stored on the data storage device(s) **504**, stored on the memory device(s) **506**, and/or communicated via the ports **508-512**, thereby transforming the computer system **500** in FIG. **5** to a special purpose machine for implementing the operations described herein. Examples of the computer system **500** include personal computers, terminals, workstations, mobile phones, tablets, laptops, personal computers, multimedia consoles, gaming consoles, set top boxes, and the like.

The data storage devices **504** may include any non-volatile data storage device capable of storing data generated or employed within the computing system **500**, such as computer executable instructions for performing a computer process, which may include instructions of both application programs and an operating system (OS) that manages the various components of the computing system **500**. The data storage devices **504** may include, without limitation, magnetic disk drives, optical disk drives, solid state drives (SSDs), flash drives, and the like. The data storage devices **504** may include removable data storage media, non-removable data storage media, and/or external storage devices made available via a wired or wireless network architecture with such computer program products, including database management products, web server products, application server products, and/or other additional software components. Examples of removable data storage media include Compact Disc Read-Only Memory (CD-ROM), Digital Versatile Disc Read-Only Memory (DVD-ROM), magneto-optical disks, flash drives, and the like. Examples of non-removable data storage media include internal magnetic hard disks, SSDs, and the like. The memory devices **506** may include volatile memory (e.g., dynamic random access memory (DRAM), static random access memory (SRAM), etc.) and/or non-volatile memory (e.g., read-only memory (ROM), flash memory, etc.).

Computer program products containing mechanisms to effectuate the systems and methods in accordance with the presently described technology may reside in the data storage devices **504** and/or the memory devices **506**, which may be referred to as machine-readable media. It will be appreciated that machine-readable media may include any tangible non-transitory medium that is capable of storing or encoding instructions to perform any of the operations of the present disclosure for execution by a machine or that is capable of storing or encoding data structures and/or modules utilized by or associated with such instructions. Machine-readable media may include a single medium or multiple media (e.g., a centralized or distributed database, and/or associated caches and servers) that store the executable instructions or data structures.

In some implementations, the computer system **500** includes ports, such as an input/output (I/O) port **508**, a communication port **510**, and a sub-systems port **512**, for communicating with other computing, network, or vehicle devices. It will be appreciated that the ports **508-512** may be combined or separate and that more or fewer ports may be included in the computer system **500**.

The I/O port **508** may be connected to an I/O device, or other device, by which information is input to or output from the computing system **500**. Such I/O devices may include, without limitation, input devices, output devices, and/or environment transducer devices.

In one implementation, the input devices convert a human-generated signal, such as, human voice, physical movement, physical touch or pressure, and/or the like, into electrical signals as input data into the computing system **500** via the I/O port **508**. Similarly, the output devices may convert electrical signals received from computing system **500** via the I/O port **508** into signals that may be sensed as output by a human, such as sound, light, and/or touch. The input device may be an alphanumeric input device, including alphanumeric and other keys for communicating information and/or command selections to the processor **502** via the I/O port **508**. The input device may be another type of user input device including, but not limited to: direction and selection control devices, such as a mouse, a trackball, cursor direction keys, a joystick, and/or a wheel; sensors, such as a camera, a microphone, a positional sensor, an orientation sensor, a gravitational sensor, an inertial sensor, and/or an accelerometer; and/or a touch-sensitive display screen ("touchscreen"). The output devices may include, without limitation, a display, a touchscreen, a speaker, a tactile and/or haptic output device, and/or the like. In some implementations, the input device and the output device may be the same device, for example, in the case of a touchscreen.

The environment transducer devices convert one form of energy or signal into another for input into or output from the computing system **500** via the I/O port **508**. For example, an electrical signal generated within the computing system **500** may be converted to another type of signal, and/or vice-versa. In one implementation, the environment transducer devices sense characteristics or aspects of an environment local to or remote from the computing device **500**, such as, light, sound, temperature, pressure, magnetic field, electric field, chemical properties, physical movement, orientation, acceleration, gravity, and/or the like. Further, the environment transducer devices may generate signals to impose some effect on the environment either local to or remote from the example computing device **500**, such as, physical movement of some object (e.g., a mechanical actuator), heating or cooling of a substance, adding a chemical substance, and/or the like.

In one implementation, a communication port **510** is connected to a network by way of which the computer system **500** may receive network data useful in executing the methods and systems set out herein as well as transmitting information and network configuration changes determined thereby. Stated differently, the communication port **510** connects the computer system **500** to communication interface devices configured to transmit and/or receive information between the computing system **500** and other devices by way of wired or wireless communication networks or connections. Examples of such networks or connections include, without limitation, Universal Serial Bus (USB), Ethernet, Wi-Fi, Bluetooth®, Near Field Communication (NFC), Long-Term Evolution (LTE), and so on. Such communication interface devices may be utilized via the communication port **510** to communicate with other machines, either directly over a point-to-point communication path, over a wide area network (WAN) (e.g., the Internet), over a local area network (LAN), over a cellular (e.g., third generation (3G) or fourth generation (4G)) network, or over another communication means. Further, the communication port **510** may communicate with an antenna for electromagnetic signal transmission and/or reception. In some examples, an antenna may be employed to receive Global

Positioning System (GPS) data to facilitate determination of a location of a machine, vehicle, or another device.

The computer system **500** may include a sub-systems port **512** for communicating with systems related to a vehicle to control an operation of the vehicle **102** and/or exchange information between the computer system **500** and sub-systems of the vehicle. Examples of such sub-systems of a vehicle, include, without limitation, imaging systems, radar, lidar, motor controllers and systems, battery control, fuel cell or other energy storage systems or controls in the case of such vehicles with hybrid or electric motor systems, autonomous or semi-autonomous processors and controllers, steering systems, brake systems, light systems, navigation systems, environment controls, entertainment systems, and the like.

In an example implementation, vehicle lighting information and software and other modules and services may be embodied by instructions stored on the data storage devices **504** and/or the memory devices **506** and executed by the processor **502**. The computer system **500** may be integrated with or otherwise form part of a vehicle. In some instances, the computer system **500** is a portable device that may be in communication and working in conjunction with various systems or sub-systems of a vehicle.

The system set forth in FIG. **5** is but one possible example of a computer system that may employ or be configured in accordance with aspects of the present disclosure. It will be appreciated that other non-transitory tangible computer-readable storage media storing computer-executable instructions for implementing the presently disclosed technology on a computing system may be utilized.

In the present disclosure, the methods disclosed may be implemented as sets of instructions or software readable by a device. Further, it is understood that the specific order or hierarchy of steps in the methods disclosed are instances of example approaches. Based upon design preferences, it is understood that the specific order or hierarchy of steps in the method can be rearranged while remaining within the disclosed subject matter. The accompanying method claims present elements of the various steps in a sample order, and are not necessarily meant to be limited to the specific order or hierarchy presented.

The described disclosure may be provided as a computer program product, or software, that may include a non-transitory machine-readable medium having stored thereon instructions, which may be used to program a computer system (or other electronic devices) to perform a process according to the present disclosure. A machine-readable medium includes any mechanism for storing information in a form (e.g., software, processing application) readable by a machine (e.g., a computer). The machine-readable medium may include, but is not limited to, magnetic storage medium, optical storage medium; magneto-optical storage medium, read only memory (ROM); random access memory (RAM); erasable programmable memory (e.g., EPROM and EEPROM); flash memory; or other types of medium suitable for storing electronic instructions.

For the purpose of promoting an understanding of the principles of the present disclosure, reference was made to the embodiments illustrated in the drawings, and specific language was used to describe the same. It will, nevertheless, be understood that no limitation of the scope of the disclosure is thereby intended; any alterations and further modifications of the described or illustrated embodiments, and any further applications of the principles of the disclosure as illustrated therein are contemplated as would normally occur to one skilled in the art to which the disclosure relates.

While the present disclosure has been described with reference to various implementations, it will be understood that these implementations are illustrative and that the scope of the present disclosure is not limited to them. Many variations, modifications, additions, and improvements are possible. More generally, embodiments in accordance with the present disclosure have been described in the context of particular implementations. Functionality may be separated or combined in blocks differently in various embodiments of the disclosure or described with different terminology. These and other variations, modifications, additions, and improvements may fall within the scope of the disclosure as defined in the claims that follow.

What is claimed is:

1. A system comprising:

a vehicle;

sensors disposed in the vehicle;

adjustable spotlights disposed in the vehicle;

a processor; and

a non-transitory computer-readable medium storing instructions that, when executed by the processor, cause the processor to perform operations comprising:

identifying an occupant of the vehicle based on information from the sensors, wherein the identified occupant is associated with a lighting preference;

identifying an object in the vehicle based on information from the sensors, wherein the object is associated with an object database accessible to the vehicle; and

in response to determining that the object is a readable object and to a machine-learning unit having learned that the occupant reads in the vehicle while the vehicle is in motion:

receiving a lighting control signal based on the identification of the occupant, the lighting preference, and the identification of the object so as to illuminate the object; and

activating the adjustable spotlights to illuminate the occupant and the object based on the lighting control signal.

2. The system of claim **1**, wherein the object is a book or newspaper, and wherein the lighting control signal directs the adjustable spotlights to provide task lighting onto pages of the book or newspaper.

3. The system of claim **1**, the operations further comprising:

activating the adjustable spotlights using a two-dimensional light emitting diode (LED) array, a lens, and one of a translation stage, a moving mirror, and an optical fiber bundle.

4. The system of claim **3**, wherein the lens is a varioptic lens.

5. The system of claim **1**, wherein the sensors comprise one or more of a global positioning system device, an imaging device, a fingerprint sensor, an iris recognition device, an eye vein verification device, a weight sensor, an electrocardiography sensor, a pressure sensor, a microphone, an ambient light sensor, an infrared antenna, or a touch screen.

6. The system of claim **1**, wherein the adjustable spotlights are adjustable and controllable time multiplexed spotlights, and wherein when activated, the adjustable and controllable time multiplexed spotlights are modulated at a rate faster than the occupant is able to perceive.

7. A method comprising:
identifying, by a processor, an occupant of a vehicle based on information from sensors associated with the vehicle, wherein the identified occupant is associated with a lighting preference;
identifying a misplaced object located in a particular zone of the vehicle based on the information from the sensors,
wherein the misplaced object is identified in response to determining that the misplaced object is not normally located in the particular zone of the vehicle and the occupant is not interacting with the misplaced object, and
wherein the particular zone is at least one of a floor of the vehicle, a footwell of the vehicle, or below a seat of the vehicle;
identifying a gaze of the occupant and movement of the occupant in respect to the misplaced object based on the information from the sensors;
receiving, by the processor, a lighting control signal based on the identification of the occupant, the lighting preference, the identification of the misplaced object, and the identification of the gaze of the occupant and the movement of the occupant in respect to the misplaced object; and
activating, by the processor, adjustable spotlights to illuminate the misplaced object and the movement of the occupant in respect to the misplaced object based on the lighting control signal.

8. The method of claim 7, further comprising:
receiving an explicit lighting command, wherein the explicit lighting command comprises one of a gesture activated command, a voice activated command, and a touch command; and
activating the adjustable spotlights based on the explicit lighting command.

9. The method of claim 8, wherein the explicit lighting command is the gesture activated command, further comprising:
activating the adjustable spotlights based on the gesture activated command, wherein the gesture activated command comprises one of a zoom command, a pinch command, and an emission area command.

10. The method of claim 9, further comprising:
controlling one of a shape, a profile, a position, an intensity, a size, and a color of illumination provided by the adjustable spotlights based on the explicit lighting command.

11. The method of claim 7, further comprising:
determining, by the processor, a current state of a vehicle based on information from sensors; and
activating the adjustable spotlights to illuminate the occupant or the misplaced object in the particular zone of the vehicle based on the current state in the particular zone.

12. The method of claim 11, further comprising:
receiving an implicit lighting command, the implicit lighting command based on a change in the current state of the vehicle; and
activating the adjustable spotlights based on the implicit lighting command.

13. The method of claim 12, further comprising:
controlling one of a shape, a profile, a position, an intensity, a size, and a color of illumination provided by the adjustable spotlights based on the implicit lighting command.

14. The method of claim 7, further comprising:
identifying that the misplaced object is no longer located in the particular zone of the vehicle based on additional information from the sensors;
receiving, by the processor, another lighting control signal based on the additional information received from the sensors; and
deactivating, by the processor, the adjustable spotlights based on the additional lighting control signal.

15. An apparatus in a vehicle comprising:
sensors;
adjustable spotlights; and
a processor configured to:
identify a first zone of the vehicle based on information from the sensors;
identify an object within the first zone of the vehicle based on information from the sensors and information from an object database accessible to the vehicle;
identify an intent of an occupant within the vehicle to interact with the object within the first zone of the vehicle, wherein the intent is identified based on the first zone, based on a gaze of the occupant and movement of the occupant in respect to the object within the first zone, and based on a lighting preference associated with the occupant;
receive a lighting control signal based on the first zone identification, the object identification, and the intent of the occupant;
activate the adjustable spotlights to illuminate the first zone and the movement of the occupant in respect to the object within the first zone based on the lighting control signal;
identify a current location of the vehicle using a global positioning sensor of the vehicle; and
in response to determining that the vehicle has previously been at the current location and that illumination of a second zone of the vehicle was previously requested at the current location,
receive another lighting control signal, and
activate the adjustable spotlights to illuminate the second zone of the vehicle.

16. The apparatus of claim 15, the processor further configured to:
determine a proximity of a mobile computing device to the vehicle and activate the adjustable spotlights based on the proximity;
determine the lighting preference based on a communication received from the mobile computing device; and
activate the adjustable spotlights based on the lighting preference.

17. The apparatus of claim 15, the processor further configured to:
illuminate a third zone when a seat of the vehicle is in a first position; and
in response to detecting that the seat is changed to a second position, illuminate a fourth zone of the vehicle.

18. The apparatus of claim 15, the processor further configured to:
determine the intent of the occupant in respect to the object based on eyes of the occupant, a head of the occupant, a hand of the occupant, and a body position of the occupant.

19. The apparatus of claim 15, the processor further configured to:
generate the adjustable spotlights using one of a liquid crystal display (LCD), an organic light emitting diode (OLED) display, a LED display, and a projection display.

20. The apparatus of claim **15**, wherein the first zone is a rear zone of the vehicle, wherein the object is a child seat located in the rear zone, and wherein the intent of the occupant is identified as getting a child seated and secured in the child seat.

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